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ECOLOGICAL ADAPTATION IN RHESUS MONKEYS AT THE KUMAON HIMALAYA¹

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(With a plate and nine text-figures)

In the western Kumaon Himalayas, the distributional range of Rhesus monkeys comprises two major habitat types coniferous forest dominated by *Cedrus deodara*, *Pinus roxburghii* and *Pinus wallichiana*, and terrace fields with potatoes, wheat, maize and peas. In the hill areas the troops always include fields as feeding places in their home ranges. During winter, as food variety decreases, the monkeys take to the seeds of pine tree as staple food. The monkey troops tend to travel to the lower part of the home range to avoid heavy snowfall, and then exploit the terrace fields more frequently than at other seasons. This is due to the scarcity of foods in the forests. It seems likely that in winter the Rhesus monkeys live milder environmental conditions than the Japanese monkeys. When some troops join and separate again at the lower elevation home ranges, there was little antagonistic behaviour. Eight categories of grouping were distinguished in the troop. Females with babies to 3-yr-olds are sociologically the basic group males which occupy the rear of troop procession function as defenders.

INTRODUCTION

Ecological and Sociological studies on the Rhesus monkey (*Macaca mulatta*) have been actively carried out in the Indian Subcontinent. Two types of ecological studies can be distin-

guished. Southwick, Beg & Siddiqi (1961a & b), Mukherjee & Mukherjee (1972), and Siddiqi & Southwick (1977) concentrated on the population ecology of the troop composition and troop density at the roadside or in streets, while Neville (1968), Lindburg (1971, 1976), Makwana (1978), Teas *et al.* (1980), and Koyama & Shekar (1981) studied the general ecology, focussing on the troop composition, distribution, home range and habits. Neville

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and Lindburg dealt with changes in troop movements and food habits related to the seasonal variations in habits of the monkeys, but little attention was given to the relation between the vertical distribution of the forest zones and that of the monkeys.

Within the genus *Macaca*, the Rhesus monkey and the Japanese monkey represent species which are adapted to areas of heavy snowfall and cold winters. The Rhesus monkey shows the next most northerly distribution to the Japanese monkey and, vertically, it reaches the snowfall areas of the Himalayas. Its distribution which spreads over a large spectrum of habitats, is the widest among macaques.

I believe it is possible to show that, in the evolutionary process of expansion of *Macaca*, this monkey successfully occupied new habitats. Important in this respect, is the Rhesus monkeys' reaction to the habitat destruction brought about by human influences, and to man himself.

The present study represents the first attempt to clarify the mode of life of the Rhesus monkey from the above viewpoints.

METHODS

The survey areas included Simla, Narkanda and Sungri in Himachal Pradesh, and the road from Simla to Rampur. In the former case, data were collected periodically by direct observation of the monkeys and supplementary information was obtained from villagers. In the latter case, the data were based on mobile censuses from buses, short ground-surveys and information from the local inhabitants. Both study areas are situated in the lower Himalayas of western Kumaon (Fig. 1). The survey period covered 6 months from August, 1972. Eleven specimens of Rhesus monkeys were collected at Sungri with the cooperation of Mr. K. L. Mehta, wildlife warden of Himachal Pradesh,

for research on their geographical variation.

GENERAL HABITAT OF THE RHESUS MONKEYS

The lower Himalayas, at 2,000-3,000 m above sea level (a.s.l.), lie in the transitional zone to the Great Himalayas, and are affected by monsoons. Based on a personal communication from Mr. K. L. Mehta, the annual rainfall in Simla is 2,168 mm. However, at the upper limit of the monkey distribution, it decreases to 1,757 mm, with 50% of the precipitation occurring during July and September. Snowfalls in the same areas begin in late November, but are concentrated during December and February. It appears that snowfalls in Khadralla which is very near and at the same height as Sungri, are more frequent than in Simla since the amount of precipitation in Khadralla somewhat exceeds that in Simla (Table 1).

Terrace fields occur up to 2,600 m a.s.l. in the survey areas, forming the upper boundary of cultivation. Below this boundary, terrace fields occupied the greatest area except on the steep slopes of valleys, and in the forest reserve covering water sheds for the drinking water of Simla at Kufri, probably amounting to 40% of the total survey area.

The survey areas were occupied by coniferous forest. This was generally dominated by *Pinus*, which extended continuously in its vertical distribution, although in some forests *Cedrus deodara* and *Abies* were dominant. *Picea*, *Juniperus*, and *Taxus* were found sporadically in the forests.

The genus *Pinus* was represented by *P. roxburghii* and *P. wallichiana*. Their distribution ranges were 500-2,200 m a.s.l. and 2,000-3,000 m a.s.l., respectively (Fig. 2). In the survey areas, *Pinus*-dominated forests were especially well developed on southern slopes, as indicated previously by Stainton (1972).

Evergreen broad-leaved forests in which

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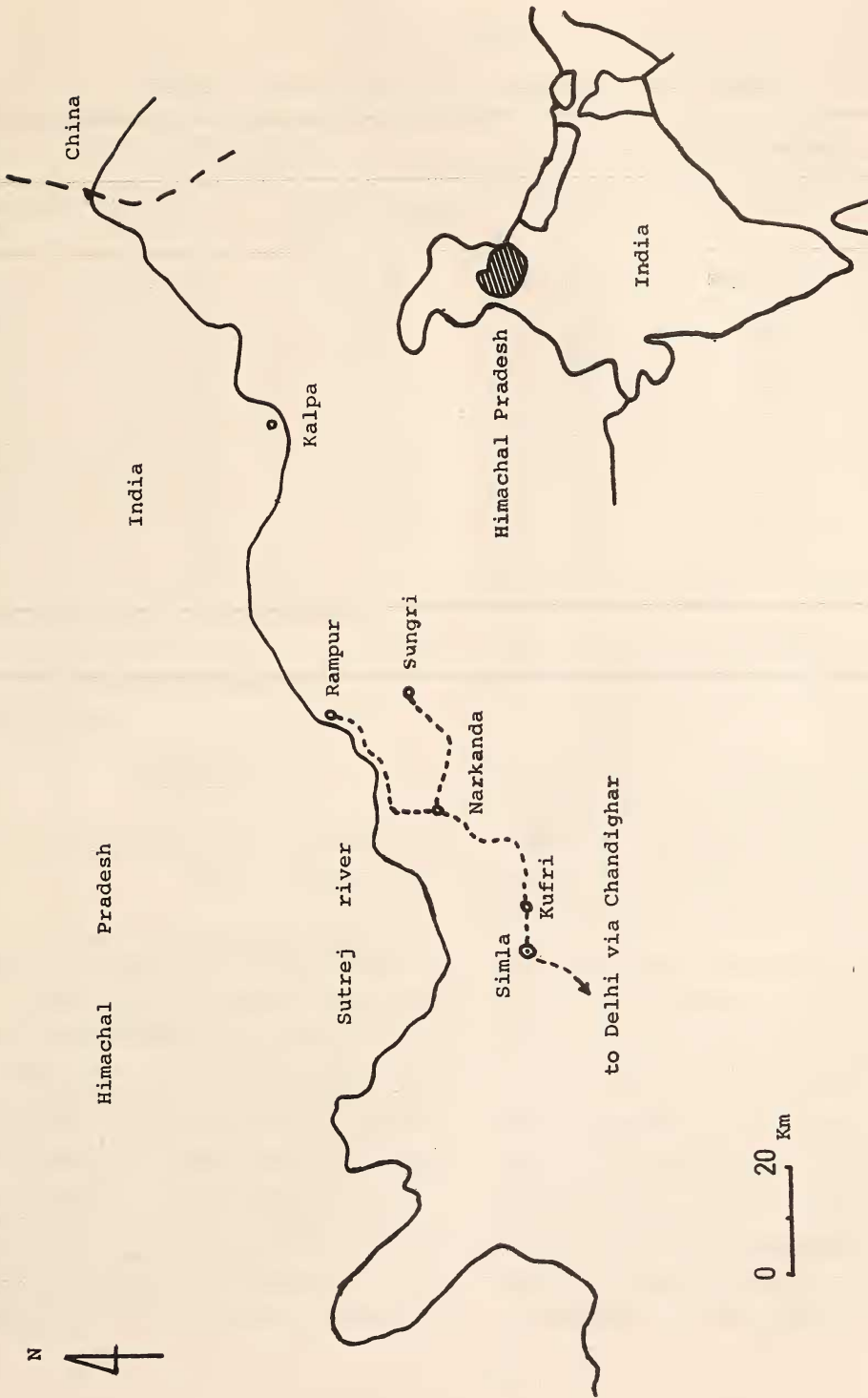


Fig. 1. Map of survey areas.

TABLE 1

MONTHLY MEAN RAINFALL IN SIMLA AND KHADRALA, 1951-1960

	Khadralla (2,600 m a.s.l.)		Simla (2,000 m a.s.l.)		
	Rainfall amount	No. of days rainfall	Rainfall amount	Mean air temperature max.	min.
Jan.	213.4 mm	6.6 days	66.3 mm	23.6°C	1.9°C
Feb.	93.2	4.8	74.2	9.3	2.3
Mar.	121.2	0.6	59.9	13.9	6.4
Apr.	70.9	0.4	46.0	18.4	10.3
May	88.4	—	64.3	22.9	13.9
Jun.	89.4	—	153.4	23.9	15.9
Jul.	384.6	—	414.0	21.6	15.1
Aug.	321.1	—	428.0	20.2	15.1
Sep.	166.9	—	423.7	20.2	13.5
Oct.	77.5	—	299.7	17.9	12.3
Nov.	13.0	0.6	132.3	14.6	6.8
Dec.	116.6	2.2	6.1	17.8	9.7
Total	1,756.7		2,168.0		

(after K. L. Mehta)

Quercus were dominant, occurred as large patches in the coniferous forest zone. The vertical distribution of species was as follows: *Quercus glauca* below 1,500 m a.s.l., *Q. incana* at 1,500-2,000 m, and *Q. semecarpifolia* at 2,000-3,000 m.

Deciduous broad-leaved trees were found sporadically as forest constituents in the above-mentioned forests. The species included *Betula alnoides*, *Aesculus indica*, *Robinia pseudocacia*, *Pyrus pashia*, *Rosa sericea*, etc.

All these forests were utilized as grazing grounds for cattle, sheep and goats. The forest undergrowth was severely reduced by grazing and stamping, and the scrub layer was poorly developed. Observation of the monkeys was thus easy under the forest canopy, the visibility and general working conditions being good.

RESULTS

The Rhesus monkey distribution and forest-cropland complex

In Simla, Kufri, Narkanda, Sungri and Rampur, where direct observations and collecting of encounter information were carried out, and along the roadside between Simla and Rampur, where rough observations were made from buses, monkey troops are continuously distributed. Around Simla, Kufri, Narkanda and Sungri, the home range of a troop includes both types of habitats, i.e., cultivated terrace and forest (Figs. 3, 4 and 5). Rhesus monkeys were never found in large forest patches such as the Gren Forest in Simla (*Quercus*-dominated), the coniferous forest of the southern

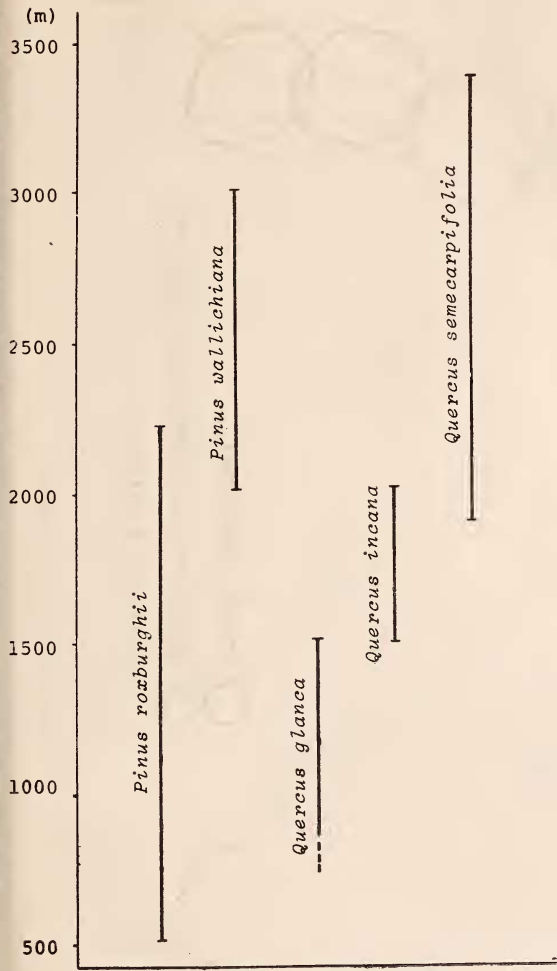


Fig. 2. Vertical distribution of pine and oak in the survey area.

slope at Kufri, and the huge coniferous forest of the northern slope at Sungri.

The upper limit of the monkey distribution coincides with the upper border of crop cultivation. In both Narkanda and Sungri, the upper border of crop fields reaches 2,600 m a.s.l., and monkey troops ranged up to 2,600 m, appearing in terrace fields at intervals and feeding on the

crops. The forest zone goes up to 3,300 m on the southern slopes of Murali Danda, 3 km north-east of Sungri. In this area of increasing elevation, *Quercus semecarpifolia* is continued and *Abies* and *Picea* are gradually mixed into *Pinus*-dominated forest, but this change in composition does not affect the monkey distribution.

The population size in each village is at the level of several hundreds; The villagers never supply monkeys with food, and the monkeys do not approach village houses to search the kitchen middens. Simla (population 200,000) is situated on a narrow ridge running north-east to south-west at 1,550-2,000 m a.s.l., and is surrounded by *Pinus roxburghii*-dominated and *Quercus semecarpifolia*-dominated forests, which are favourable habitats for Rhesus monkeys. The township of Simla is 4 km long and 1 km wide. Ten monkey troops travel around temple gardens, markets and hospitals without utilizing the surrounding forest patches, so their home ranges were confined to the streets of Simla (Fig. 6).

Activity pattern of troops

Generally, Rhesus monkeys take many kinds of crops in terrace fields and other cultivated fields in India (Neville 1968, Mukherjee 1969). The times spent in the two areas were 78% in forests and 22% in fields (Table 2). However, remarkable differences were noted in the number of hours that the troop stayed in the fields among the survey areas. These differences depend upon the farmers' attitude.

To simplify the description of ecologically important individual activities, I classified their activities into 7 categories: Moving, feeding, sitting, grooming, playing, mounting and quarrelling.

In terrace fields: Almost all individuals of each troop except in Simla and Kufri were

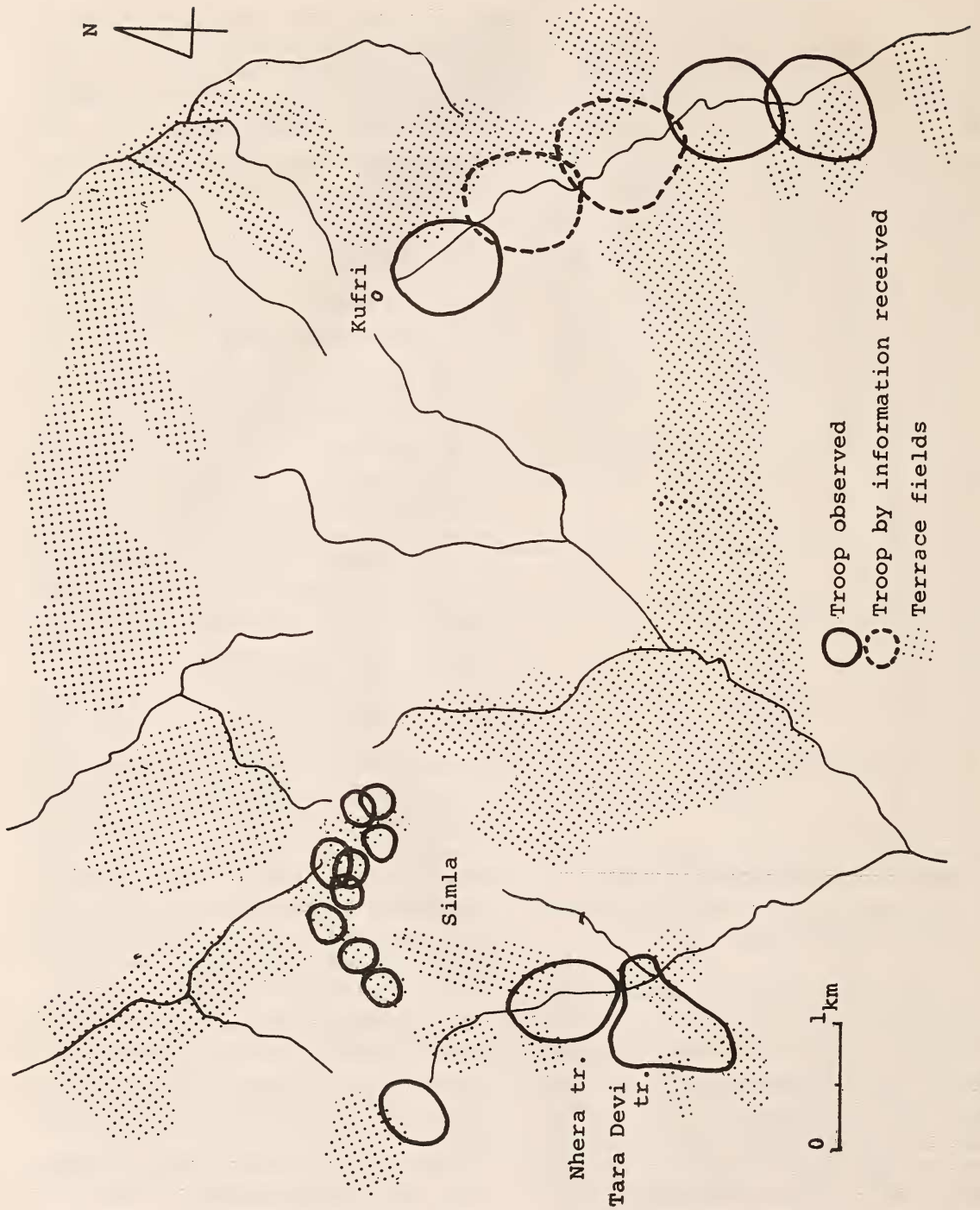


Fig. 3. Troop distribution at Simla.

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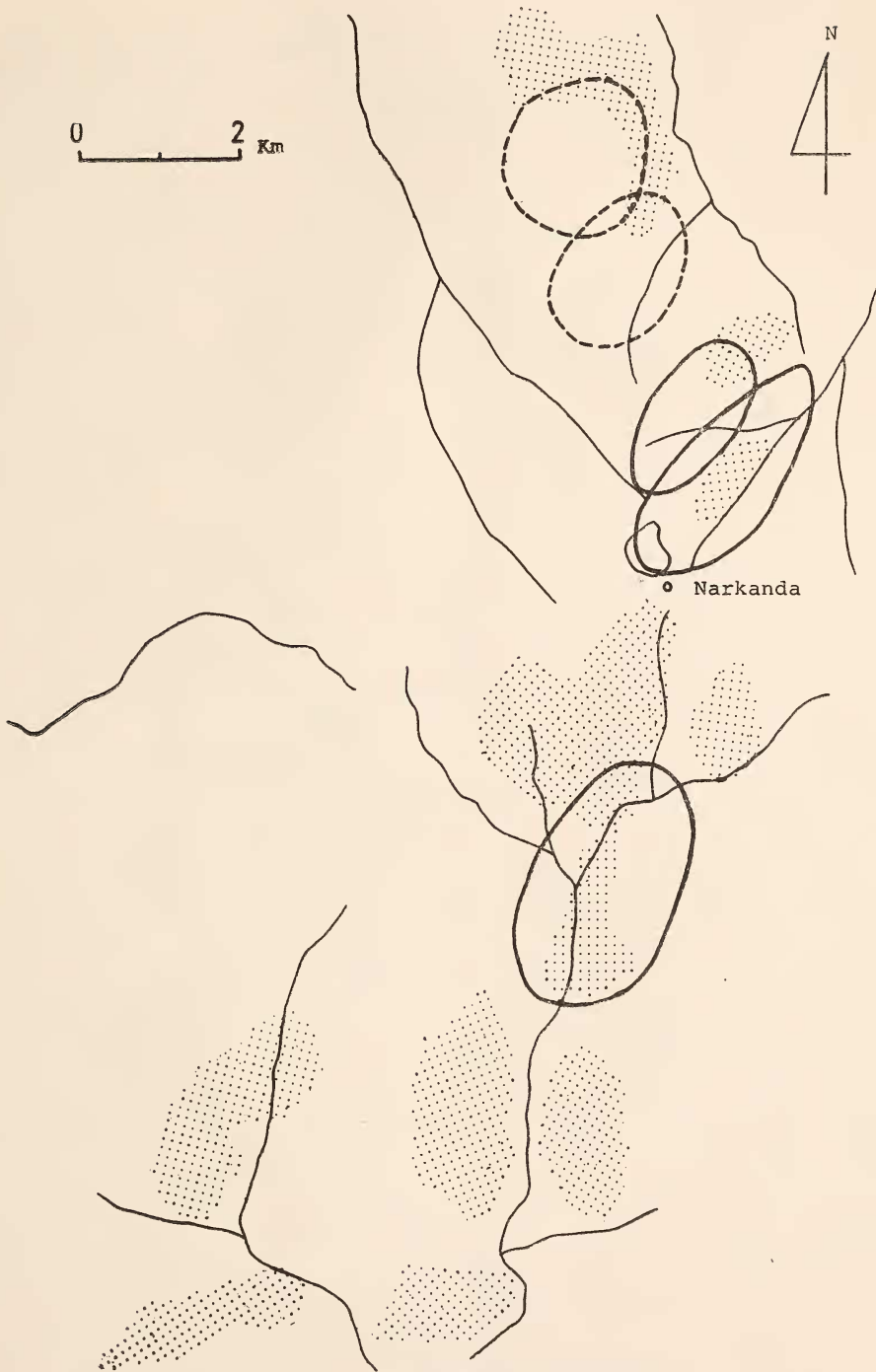


Fig. 4. Troop distribution at Narkanda.

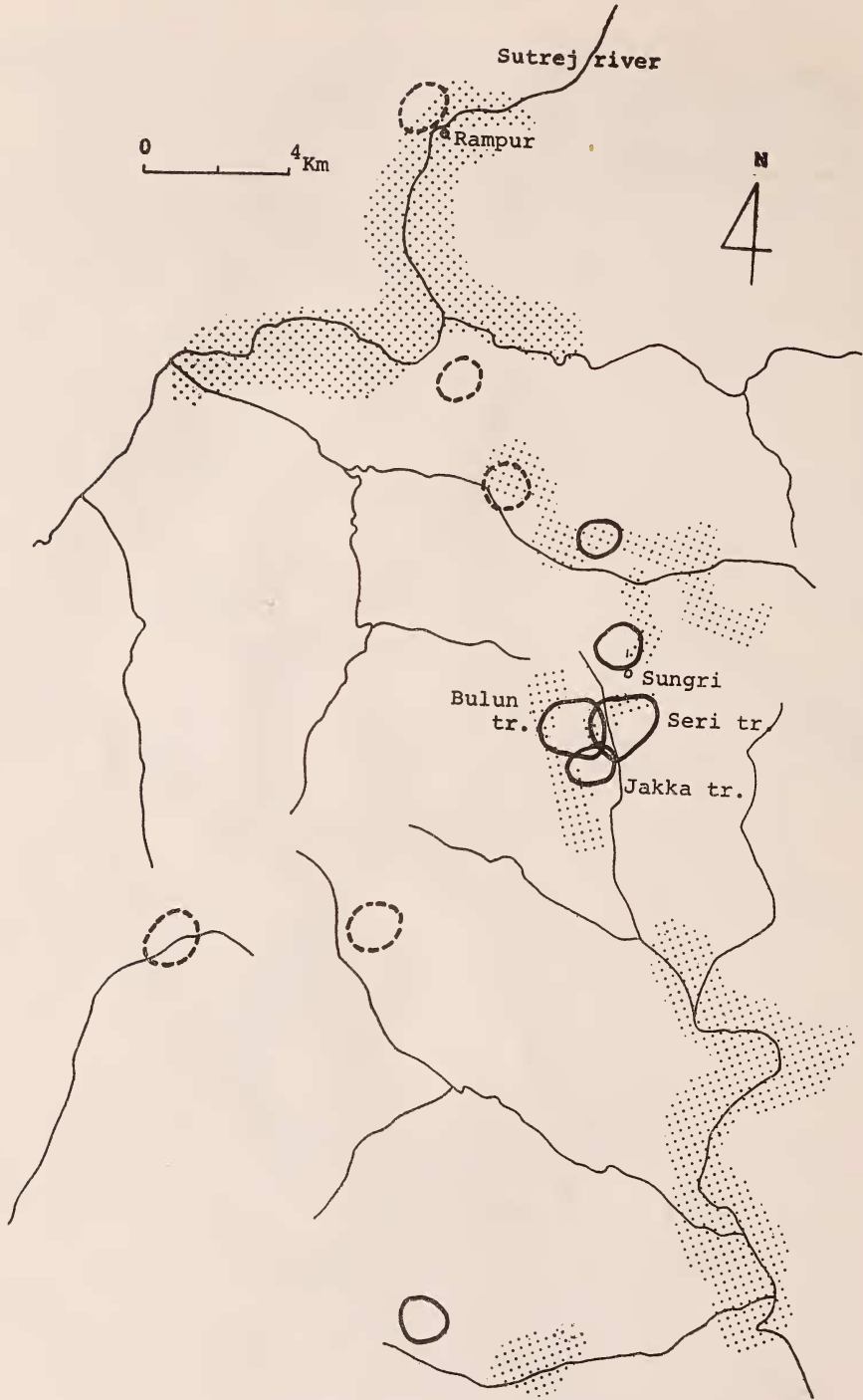


Fig. 5. Troop distribution at Sungri.

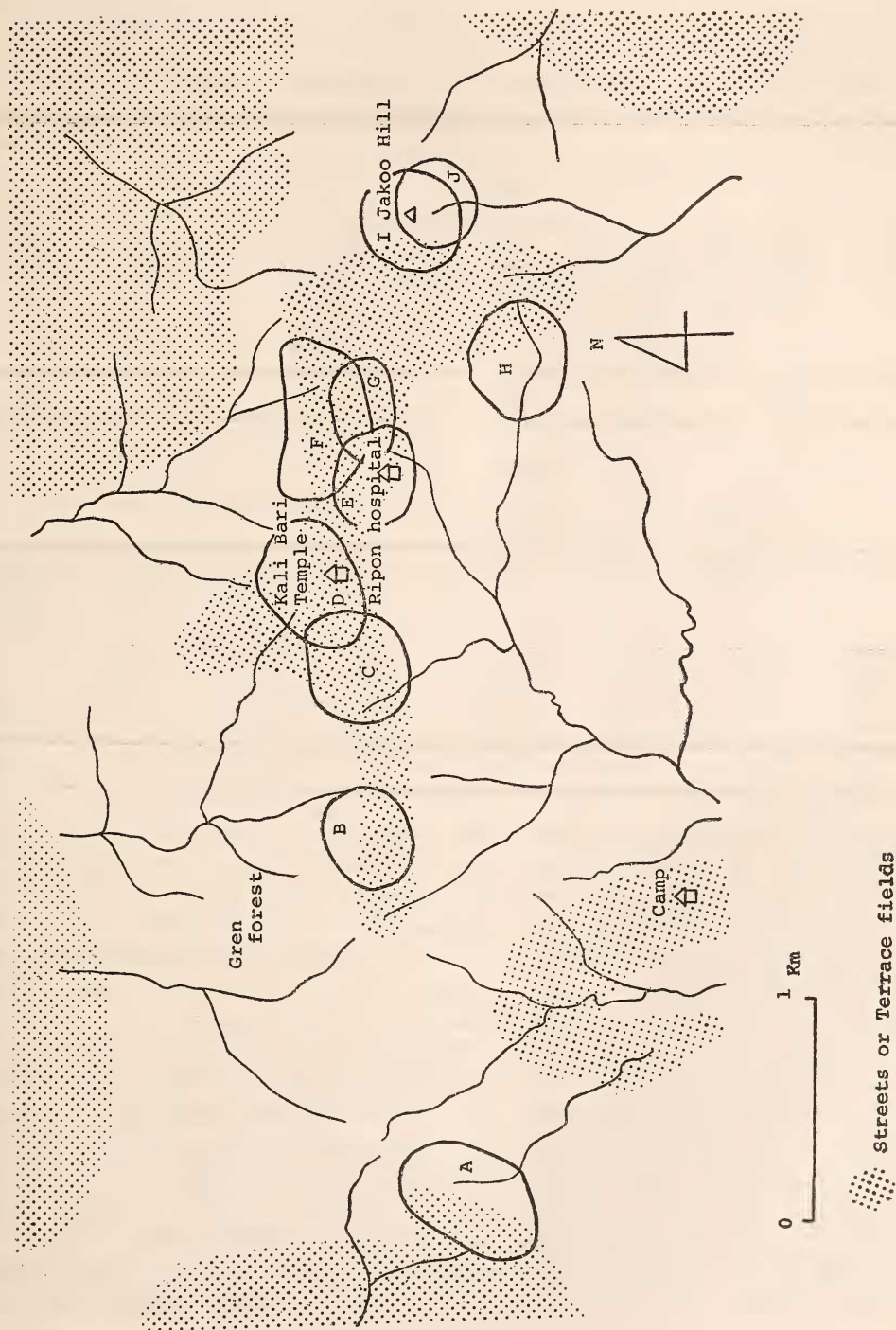


Fig. 6. Troop distribution in and around Simla.

A: Bioleaugang troop; B: Cecil troop; C: Assembly troop; D: Kali Bari Temple troop; E: Ripon Hospital troop; F: Ridge troop; G: Lower Bazar troop; H: View troop; I: Jakoo Temple I troop; J: Jakoo Temple II troop.

TABLE 2

UTILIZATION OF THE MONKEY TROOPS IN FORESTS AND TERRACE FIELDS

Area	Period observed	Observation time (hr)			Days observed
		Total	In forests	In fields	
Simla and Kufri	Sept, 1972 — Jan, 1973	20.3	20.3	0	22
Narkanda	Sept, 1972 — Dec, 1972	60.4	53.5	6.9	14
Sungri	Oct, 1972 — Jan, 1973	79.5	50.4	29.1	17
	Oct, 1972 — Dec, 1972	39.6	33.0	6.6	
	Jan, 1973	39.9	17.4	22.5	
Total		160.2	124.2	36.0	46

TABLE 3

ACTIVITY PERCENTAGE OF RHESUS MONKEYS IN TERRACE FIELDS

	Sitting	Grooming	Mounting	Moving	Feeding	Playing	Quarrel- ling	Number of ind. observed
Simla & Kufri	0%	0%	0%	0%	0%	0%	0%	0
Narkanda	2.1	4.5	0.8	15.7	76.4	0.4	0	242
Sungri	10.6	6.9	0.3	34.1	47.1	0.7	0.3	1371
Total	9.2	6.5	0.4	31.4	51.5	0.7	0.3	1613

counted in terrace fields. Monkey troops spent most of the time feeding in the terrace fields. Because the troops were not chased away from the fields by farmers or dogs in Sungri, they spent the remainder of the time moving, sitting and grooming in the fields (Table 3).

The individuals of a troop did not spread out in terrace fields where there were watchmen. Adult animals picked up food, e.g., corn, in the fields and usually returned immediately to the forest fringe to eat slowly. In the fields where there were no watchmen, the members of the monkey troop spread out in the fields without disturbance, keeping the original spacing among individuals, so in some cases adult females, babies and juveniles appeared in the

fields from the top group of a troop. They gradually spread throughout the fields without indications of tension or fear. When farmers approached to within 20 m they ran into the forest, but remained near the edge of the forest canopy. When the farmers left, they usually returned to the fields again.

There are differences in farmers' attitudes to chasing the monkeys, depending on the kind of crop. Corn is rigorously protected, followed by peas and buckwheat, but autumn sown wheat and potatoes are almost neglected. Corresponding to the farmers' interest, the Rhesus monkeys behave in different ways in the fields according to the nature of the crop. They are tense when they forage for corn, but are at

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ease when foraging for autumn sown wheat or potatoes, etc. In Nhera village and Mulong village near Simla the corn harvest was little damaged by the monkeys, being kept effective-

members were recorded every observation time. Out of 124 hr observation in forests, feeding accounted for 26.9% of the total activities (Table 4).

TABLE 4
ACTIVITY PERCENTAGE OF RHESUS MONKEYS IN FORESTS

	Sitting	Grooming	Mounting	Moving	Feeding	Playing	Quarrel- ling	Number of ind. observed
Simla & Kufri	16.4%	3.7%	0 %	48.3%	28.1%	1.7%	1.7%	402
Narkanda	10.5	7.6	1.4	43.5	33.4	2.3	1.4	740
Sungri	8.8	8.6	1.6	56.2	21.7	0.6	2.6	1025
Total	10.8	7.3	1.2	50.4	26.9	1.4	2.0	2167

ly under watch. In Dhalar village and in Nheri village near Narkanda, waste potatoes after the harvest and wheat were the main targets of the monkeys' foraging. Along the main paths of movement of the troops throughout Dhalar village and Nheri village (Narkanda) and Tikkri village, Balun village and Sunmarkot village (Sungri), the troops probably caused little harvest damage because they spread out and rested in the fields, and picked young leaves of autumn sown wheat.

The frequency of appearance in the terrace fields increased remarkably in winter in relation to the snowfall. This point will be discussed later.

Although children at times threw stones to the monkeys, people in Simla do not chase Rhesus monkeys, because of religious sentiments. In the streets of Simla, people sometimes gave food to monkeys, but continuous provisioning is practised only for the troops at Jakoo Temple and Kali Bali Temple. Other troops forage mostly at dumping grounds, in grasslands or in small thickets in gardens.

In forests: More than 60% of all troop

Judging from these tables, the amount of feeding was presumed to be greater in the fields than in the forests. However, it is not yet known whether differences exist between feeding ability in forests and feeding in fields.

Food list of Rhesus monkeys

The main food in the forests consisted of fruits, nuts, seeds, leaves and stems of various trees and grasses. Seeds of trees such as *Pinus roxburghii*, *P. wallichiana*, leaves of *Berberis aristata*, leaves and stems of *Trifolium repens* comprised the staple food during the survey period, but fruits of *Vitis himalayana* are eaten during October and November. Fruits and leaves of *Quercus incana* and *Q. semecarpifolia*, and fruits, leaves, stems and grains of plants were substaple or temporary food. Table 5 shows the main food items and their utilization. The trees and the grasses that comprise the staple foods were the most common species in the home ranges of the troops. Lindburg (1976) described the foods of 92 species in the tropical forest, and that the staple foods are composed of common species in the forest.

TABLE 5

FOOD LIST OF RHESUS MONKEYS

Feeding area	Kind of food	Family	Part eaten	Frequency of eating	Period as staple food
Forest	<i>Pinus roxburghii</i>	Pinaceae	Seed	Extremely often	Sept.-Jan.
	<i>Pinus wallichiana</i>	Pinaceae	Seed, Leaf	Extremely often	Sept.-Jan.
	<i>Cedrus deodara</i>	Pinaceae	Leaf	Rarely	
	<i>Quercus incana</i>	Fagaceae	Fruit, Leaf	Frequently	
	<i>Quercus semecarpifolia</i>	Fagaceae	Fruit	Frequently	
	<i>Prunus cornuta</i>	Rosaceae	Fruit	Frequently	
	<i>Osyris arborea</i>	Cornaceae	Fruit	Rarely	
	<i>Rosa moschatta</i>	Rosaceae	Fruit	Frequently	
	<i>Cotoneaster affinis</i> var. <i>basillaris</i>	Rosaceae	Fruit	Rarely	
	<i>Reinwardtia trigyna</i>	Linaceae	Leaf	Frequently	
	<i>Berberis aristata</i>	Berberidaceae	Leaf	Very often	Sept.-Jan.
	<i>Syringa</i> sp.	Oleaceae	Fruit	Frequently	
	<i>Tilia europaea</i>	Tiliaceae	Fruit	Rarely	
	Tiliaceae		Bark	Rarely	
	<i>Ficus sarmentosa</i>	Moraceae	Fruit	Frequently	
	<i>Vitis himalayana</i>	Vitaceae	Fruit	Extremely often	Oct.-Nov.
	<i>Trifolium repens</i>	Leguminosae	Stem, Leaf	Extremely often	Sept.-Jan.
	<i>Rumex crispus</i>	Polygonaceae	Leaf	Frequently	
	<i>Rumex acetosa</i>	Polygonaceae	Leaf	Frequently	
	<i>Fragalia nubicola</i>	Rosaceae	Stem, Leaf	Frequently	
	<i>Duchesnea indica</i>	Rosaceae	Stem, Leaf	Frequently	
	<i>Stellaria media</i>	Caryophyllaceae	Leaf	Frequently	
	<i>Poa anna</i>	Gramineae	Stem, Leaf	Frequently	
	<i>Sarcococca saligna</i>	Buxaceae	Fruit	Frequently	
	<i>Trichosanthes</i> sp.	Cucurbitaceae	Leaf	Rarely	
	<i>Pimpinella diversifolia</i>	Umbelliferae	Leaf	Rarely	
	Umbelliferae		Leaf	Rarely	
	<i>Plantago lanceolata</i>	Plantaginaceae	Leaf	Rarely	
	Compositae		Leaf	Frequently	
	<i>Vicia sativa</i>	Vicieae	Leaf	Frequently	
	<i>Jasminum humile</i>	Oleaceae	Leaf	Rarely	
	<i>Bothriochloa glabra</i>	Poaceae	Grain	Frequently	
	<i>Arundinella setosa</i>	Poaceae	Grain	Frequently	
<i>Pteridium aquilinum</i>	Pteridaceae	Leaf	Rarely		
Fields	Buckwheat		Grain	Rarely	
	Peas		Pod	Rarely	
	Corn		Grain	Extremely often	Aug.-Sept.
	Potatoes		Root	Extremely often	Oct.-Nov.
	Wheat		Young leaf	Extremely often	Nov.-Jan.
	Apples		Fruit	Rarely	
	Pumpkins		Fruit	Rarely	
	Beans			Frequently	
Streets	Leavings of inhabitants			Extremely often	Sept.-Jan.
	Fruit and vegetables			Frequently	
	Rice and chapati			Rarely	
	Meat and egg				

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Rhesus monkeys in the fields ate fruits, grains and roots of crops, and the leaves of autumn sown wheat. All kinds of crops cultivated in the home ranges were eaten. Corn, potato, and wheat, which were the most commonly cultivated crops were most utilized by the monkeys.

In the streets, Rhesus monkeys picked up fruits, vegetables, rice, and the remains of chapatis. Many people visiting the Jakoo Temple and the Kali Bali Temple offer dried beans, biscuits and fruits haphazardly. The amount of food given to monkeys in the temples is possibly less than that given to the Japanese monkeys which are so provisioned. Furthermore, only a few individuals can obtain food. The monkeys living in the streets eat mainly leaves and seeds of *Pinus wallichiana*, fruits of *Quercus incana*, leaves of *Rumex* sp., *Stellaria media*, grains of the Grami-

nae, and certain kinds of vines.

The Lower Bazar troop, the Ripon Hospital troop, and the Boileauganj troop live mainly on remnants of human food, and the Jakoo Temple troops and the Ridge troop are mainly dependent on trees and grasses in groves and gardens.

Troop size, distribution of Rhesus monkeys

The Tara Devi troop and the Nhera troop (Fig. 3), like troops in Narkanda and Sungri, contain more than 30 individuals, whereas the troops in the Simla streets, except for the Jakoo Temple I and II troops, contained less than 30 individuals (Table 6). Therefore, the sizes of troops in natural habitats were bigger than those of troops in the Simla streets, except for the Jakoo Temple I and II troops. The Jakoo troops occupy *Cedrus deodara*-dominated forests around this temple, so that environ-

TABLE 6
TROOP SIZE OF RHESUS MONKEYS

Area	Troop	No. of individuals	Kinds of habitat
Simla	Tara Devi	33	Forests and fields
	Nhera	20-25	"
	Jakoo Temple I	49	Forests along streets
	Jakoo Temple II	44	"
	Ridge	30	Streets
	Lower Bazar	c 20	"
	Rippon Hospital	15	"
	Assembry	26	"
	Karivali Temple	c 30	"
	Cecil	15	"
Narkanda	Boileauganj	8	"
	View	4	"
Narkanda	Dosa	37	Forests and fields
	Nheri	36	"
Sungri	Seri	46	Forests and fields
	Balun	50	"
	Jakka	37	"

mental conditions are different compared to those of troops in the streets. Furthermore, these two troops obtained diverse foods from people visiting the temple. The other troops living in the streets could not get food from people, but foraged in domestic refuse and other items around Simla.

The home range of the ten troops in the Simla streets (4 km x 1 km) overlapped widely and avoided the *Quercus incana*-dominated and *Pinus roxburghii*-dominated forests near the streets (Fig. 6). On the other hand, troops having fields and forests as home ranges were

continuously distributed so that the home ranges were in contact, and sometimes overlapped (Figs. 3, 4 and 5).

The size of the 7 troops occupying forest and field averaged 37.4 individuals, ranging from 23 to 50.

Forests and terrace fields in the home range

The boundary of the home range was defined as the line connecting the outermost travelling routes. The sizes of the home ranges in Narkanda and Sungri were observed over comparatively long periods, it was difficult to

TABLE 7
SIZE OF THE HOME RANGE OF TROOPS

Area	Troop	Maximum diameter of home range (km)	Home range (km ²)			
			Forest	Field	Total	per ind.
Simla	Tara Devi	2.0				
	Nhera	2.6				
	Jakoo Temple I	<0.5				
	Jakoo Temple II	"				
	View	"				
	Ridge	"				
	Lower Bazar	"				
	Rippon Hospital	"				
	Kalivali Temple	"				
	Mall	"				
	Cecil	"				
Boileauganj	"					
Kufri	Swaya	2.4				
	Nara	2.3				
	Bagna	"				
	Vahila	"				
Narkanda	Nheri	2.1	1.0	0.5	1.5	0.04
	Doza	1.3	0.5	0.1	0.6	0.02
	Deolidhar	2.6				
Sungri	Seri	3.0	1.7	0.7	2.4	0.05
	Balun	3.4	3.4	1.3	2.6	0.05
	Jakka	c3.0				

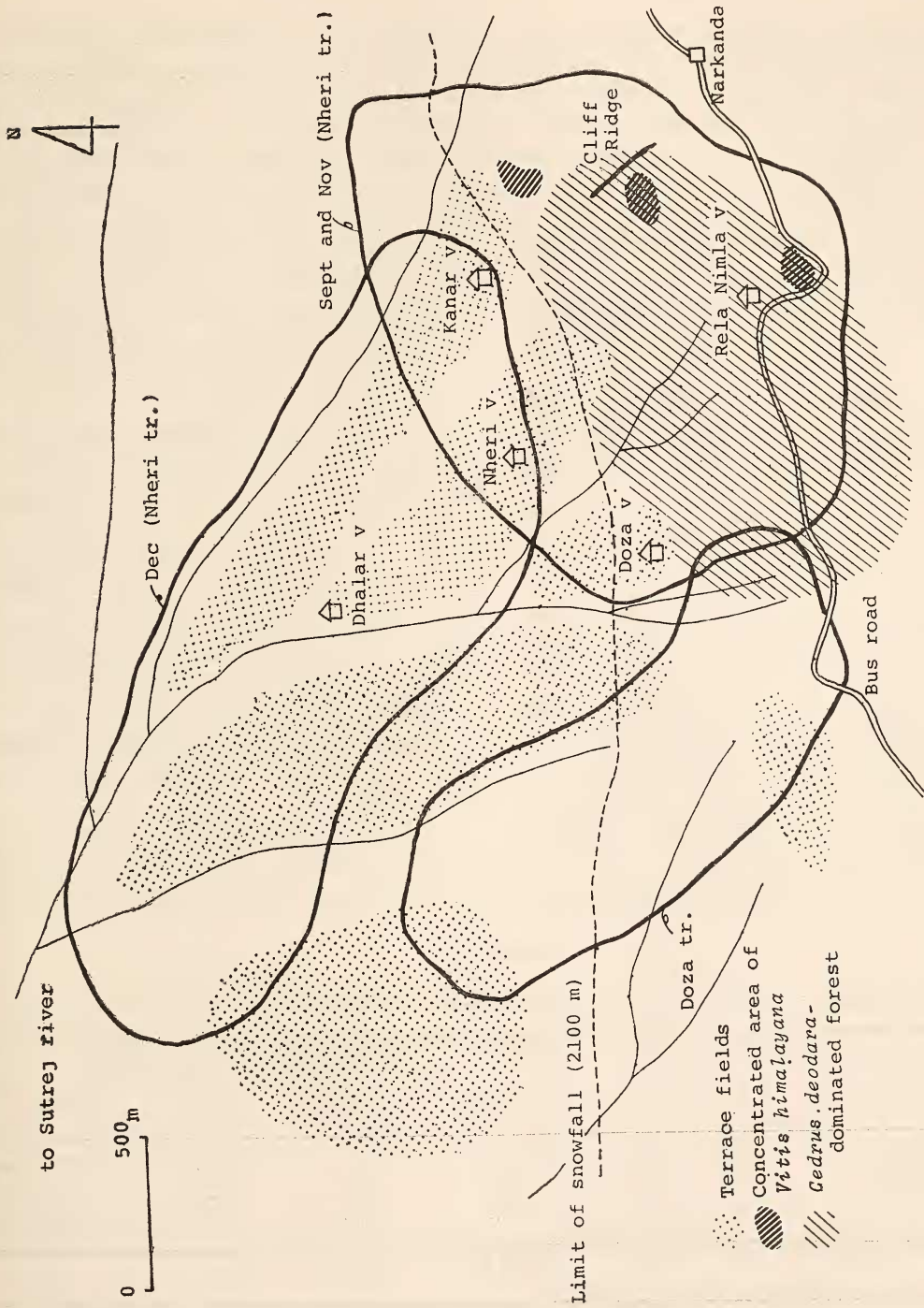


Fig. 7. Seasonal changes in utilization within the home range of the troops at Narkanda.

trace both troops in Sungri separately in January, so their separate status could not help declining. But it was possible to determine the size in other areas. In the latter cases, the maximum diameter of the home range was measured instead of the area (Table 7). Home ranges in Narkanda were smaller than at Sungri, but more extended observations might have reduced the difference.

Terrace fields accounted for 29%-50% of the home range, and are important as feeding areas.

In comparison, monkey troops in Simla moved little, presumably because the troop were dependent on kitchen midden, groves and gardens.

Changes of home range of Rhesus monkeys, and food and snowfall

In Narkanda: The troop movements changed depending on the presence of ripe fruits in the forests in autumn. In coniferous forests between Nheri village and Narkanda street (2,200-2,500 m a.s.l.) there were three places where clusters of *Vitis himalayana* grow together with coniferous trees, i.e., opposite Rela Nimla, near the cliff ridge, and in the upper part of Kanar village (Fig. 7).

Fruits of *Vitis himalayana* ripen fully in

Narkanda from mid-September to the end of October. I observed monkeys in mid-September and in early October in that area. At this season, the Nheri troop used the area above the road lying beneath Nheri village and intensively utilized the coniferous forest beyond Nheri village. The above-mentioned clusters of *Vitis himalayana* were included within their daily travelling course. Although I was informed that the troops appeared in corn, potato, and pea fields around Nheri village, the troops chiefly utilized food in forests during this period.

The leaves of trees gradually start to turn yellow in early October, and broad-leaved trees and most of the undergrowth are defoliated at the end of October. At the same time, fruits of *Vitis himalayana* fall. As a result, food variability becomes low, and the kind of food available decreases. Seeds of *Pinus wallichiana*, fruits of *Quercus semecarpifolia*, and *Rosa moschatta*, and certain other trees, leaves and stems of *Trifolium repens*, and leaves of the Gramineae were eaten remarkably. All these plants covered the whole home range of the Nheri troop.

At the end of November and the end of December, the Nheri troop travelled around Nheri village and Dhalar village, situated down-

TABLE 8

UTILIZATION RATES OF FORESTS AND TERRACE FIELDS IN THE HOME RANGE OF THE NHERI-DOZA TROOPS

Survey period	Utilized amount of home range (hr)			
	Forests	Fields	Total	Troop
Sept.-Oct., 1972	29.0	0	29.0	Nheri troop
Nov.-Dec., 1972	15.3	6.4	21.7	„
Dec., 1972	9.2	0.6	9.8	Dosa troop
Total	53.5	7.0	60.5	

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TABLE 9
SNOWFALL DATA FOR SIMLA, NARKANDA AND SUNGRI

Date	Snowfall amount		
	Simla	Narkanda	Sungri
1972	Nov. 24, rainstorm	Nov. 24, snowfall 20 cm	Nov. 24, snowfall
		Nov. 25-29, snow remaining on southern slopes	Dec. 9, snowfall 40 cm
		early Dec., snowfall	Dec. 10-12, snow remaining on southern slopes
			Dec. 19, snowfall 40 cm
1973		Dec. 19, snowfall 30 cm	Jan. 8-9, snowfall 20 cm
	Jan. 7, rainfall	Dec. 28, snowfall 30 cm	Jan. 12, snowstorm 60 cm
	mid-Jan. snowfall	early Jan., snowfall	Jan. 18, snowfall 10 cm
		mid-Jan., snowfall	Jan. 20, snowfall 40 cm
	Jan. 27, snowfall 20 cm	end of Jan., snowfall	

(observed by Wada)

stream from Nheri village. At this season, the variety of food decreased as already mentioned, and the duration of stay in the terrace fields increased greatly (Table 8). Although the monkey troop partly utilized the fields as a home range in September and October, it moved chiefly in the forests. However, by the end of November the troop spent most of its time in the fields, and sometimes remained in the same field without being chased by farmers or dogs, as seen on 29th November. In this season, potatoes were harvested, but considerable amounts of left-overs remained in the fields, while the autumn sown wheat was about 20 cm long in sporadic distribution between Nheri village and Dhaler village.

The main food sources of the Rhesus monkeys in this season in the terrace fields were potato remnants and leaves of autumn sown wheat. All individuals of the troop spread over all parts of the fields in seeking these food items.

Snowfall was recorded 10 times from November to January, 1972-1973 (Table 9). There was about 20 cm snowfall above 2,200 m a.s.l. on 24th November, but it rained below that altitude. This snowfall remained for 6 days, and subsequently, unwithered *Trifolium repens*, and seeds of *Pinus wallichiana* were again exposed.

The Doza troop was observed at the end of December. This troop usually moved along the western ridge of Doza village utilizing the *Pinus wallichiana*-dominated forests without entering the terrace fields (Figs. 4 and 7). The home range of this troop lies between 2,000 m a.s.l. and 2,400 m a.s.l., where snow falls. Going straight down from the ridge, it touches the home range of the Nheri troop around Dhaler village. At the end of December, the Doza troop was travelling only in the forests,

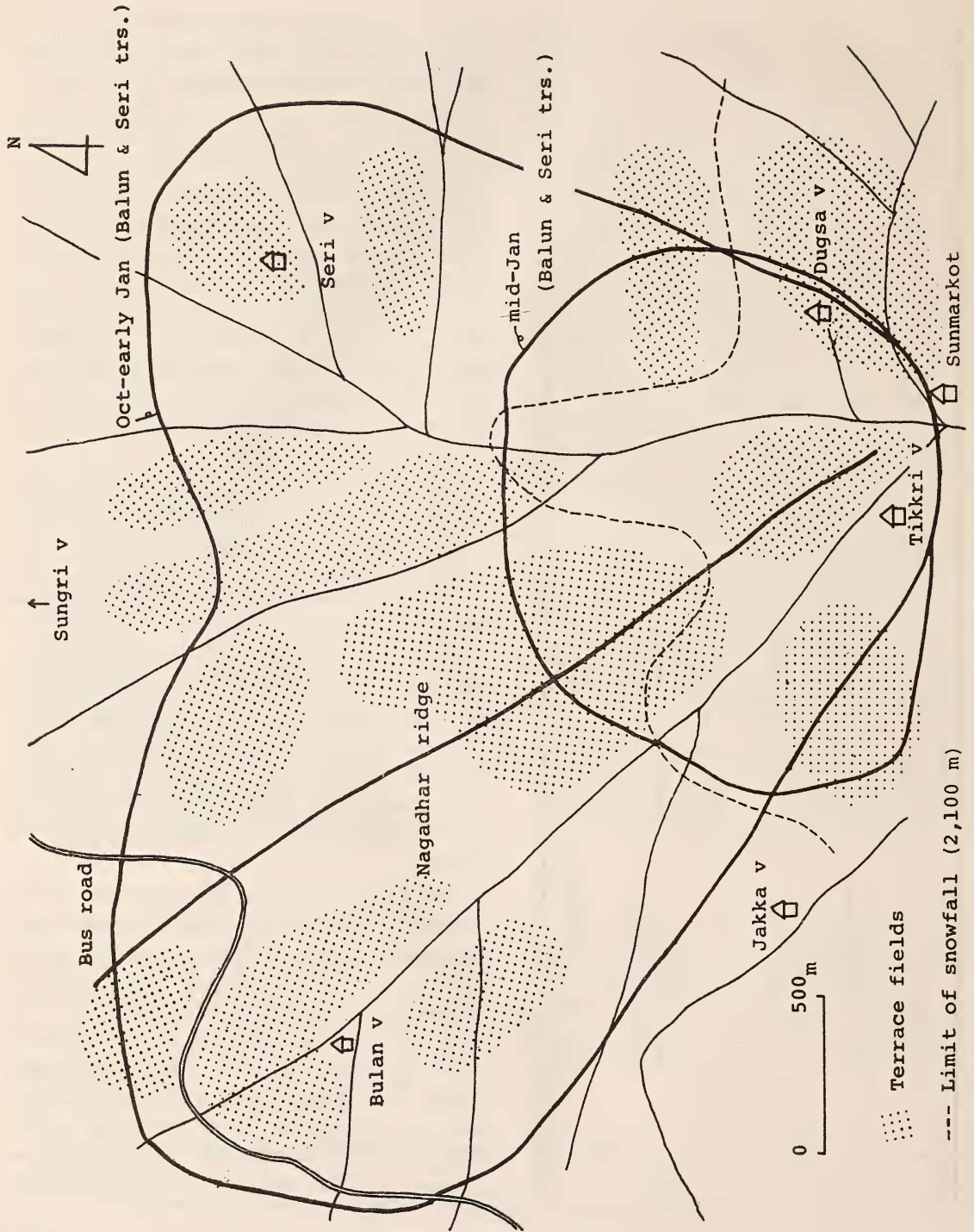


Fig. 8. Seasonal changes in utilization within the home range of the troops at Sungri.

indicating that the forests offer an adequate supply of food for the troop, contrary to the case of the Nheri troop. These findings reflect differences between the forest types of the two ranges: Deodar-dominated forests with little *Pinus wallichiana* in the Nheri troop range, and *Pinus wallichiana*-dominated forests in the Doza troop range.

In Sungri: There are differences in the utilization of home ranges between October-December and January, judging from 4 periods of observation of the Balun troop and the Seri troop during the end of October, mid-November, mid-December and mid-January. During the period between October and December, they travelled in the area between Balun village and Seri village; the lowest point reached was Sunmarkot, and the highest was near the Simla-Bhali road (Figs. 5 and 8).

The Balun troop travelled in the area of Balun village and along the Nagadhar ridge at the beginning of January and the Seri troop travelled in the area of Seri village at the same time. Since the middle of January in the survey area troops were not found. So it is sure that the Balun and Seri troops travelled near Tikkri village and Dugsa village during the middle of January, and the third troop (Jakka troop) was found at 16th January near Tikkri village, so that 3 troops utilized the area from around Tikkri village to Dugsa village, having overlapping home ranges (Fig. 8).

During my observation period, the 2 troops used the upper part of their home ranges in October-December, and the lower part in January.

The numbers of snowy days and the duration and amount of snowfall in Sungri were almost the same as those in Narkanda, which is situated at the same altitude. In Sungri, it snowed about 10 times during the period between November and the end of January, and

the time during which snow remained on the ground increased gradually. The remaining snow on the southern slopes melted within 3 or 4 days in November or December, but in January snow fell very often, so that the ground was fully covered. The snowfall on 8th, 12th, 18th and 20th January resulted in persistent snow cover above Balun village and Seri village during January. In this respect, the snowfall in January is different from that in November and December.

The Balun troop and the Seri troop chiefly travelled around Balun village and Seri village in November and December, and changed their home ranges to the region of Tikkri village and Dugsa village in January. This change in home range appeared to be related to the snowfall in these areas. They concentrated around Tikkri village and Dugsa village, where there was no snowfall in January, while higher regions were covered with snow.

Snow cover on the ground affects the movement pattern of the monkeys by changing food availability. Food items during October-December were the seeds of *Pinus wallichiana*, both on the ground and in pine cones, as well as nuts and fruits of other kinds of trees, the leaves and stems of *Trifolium repens*, many kinds of grasses in the forests, remaining potatoes and young leaves of autumn sown wheat in the terrace fields. After heavy snow, only the seeds of *Pinus wallichiana* in the forest canopy remained available. One or two days after snowfall in October-December, exposed areas in the forests and the ridges of fields became clear of snow and the monkeys obtained food in such places. Since the amount and frequency of snowfall increased in January, finding food on the ground became difficult. The monkeys therefore utilized the lower part of the home range, where there were potatoes and young leaves of autumn sown wheat in

TABLE 10
DAILY TRAVEL DISTANCE OF TROOPS

in Simla			in Narkanda			in Sungri		
Date	Troop	Distance (km)	Date	Troop	Distance (km)	Date	Troop	Distance (km)
Sept., 24, 1972	Tara Devi	2.2	Sept., 18, 1972	Nheri	2.2	Dec., 8, 1972	Balun	0.4
" , 25,	"	3.1	" , 20	"	1.6	" , 9	"	0.7
Oct., 22, 1972	Nhera	0	Oct., 5, 1972	"	1.7	" , 10	"	0.6
" , 25,	"	1.6	" , 6	"	1.1	" , 11	"	0.8
" , 26,	"	0.7	Nov., 27, 1972	"	0	" , 12	Seri	1.6
Dec., 24, 1972	"	0.2	" , 28	"	1.0	" , 12	Balun	1.4
Jan., 25, 1973	"	0	" , 29	"	2.0	" , 13	Seri	0.9
			" , 30	"	2.4	" , 13	Balun	1.0
			Dec., 1, 1972	"	0.8	" , 14	Seri	4.6
			" , 22	"	1.0	" , 14	Balun	1.0
			" , 23	"	1.0	Jan., 10, 1972	"	1.5
			" , 24	"	1.8	" , 11	"	1.3
			" , 27	Doza	1.6	" , 12	"	0.4
			" , 28	Nheri	1.1	" , 13	"	1.5
			" , 30	"	1.2	" , 14	"	1.1
			" , 31	Doza	1.1	" , 15	"	0.8
			" , 31	Nheri	0.7	" , 16	B	0.9
						" , 16	A	0.7
						" , 16	Jakka	0.8
						" , 17	B	1.4
						" , 19	E	0.8

the fields, and the seeds of *P. wallichiana*, leaves of *Berberis aristata* and stems and leaves of *Trifolium repens* in the forests, avoiding the snow-covered regions in the upper part of the range.

Differences in the movement pattern of the troop appear to be related to changes in the utilization rate of the fields and the forests. The time spent by the troops in the fields and in the forests from October to December were quite different from those in January. In the period between October and December, 83.3% of the total observation time was spent in the forests and 16.7% in the fields. However, in January, only 48.4% was spent in the forests and the remaining 51.6% in the fields. There was a marked increase in the utilization of the terrace fields.

The daily travel distance of a troop was not affected by snowfall (Table 10). Footprints of monkeys in the snow immediately after snowfall were less than 20 cm deep, so the abdomen did not touch the snow surface.

In Narkanda and Sungri, the troops changed their utilization areas to below the lowest limit of snowfall after frequent snowfalls. This indicates that such a change in home range is due to difficulty in obtaining food in the presence of snow cover rather than to the low temperature or the difficulty of moving in the snow.

Before snowfalls, the troop utilized the upper part of the home range, where the members usually foraged the fruits of *Vitis himalayana*, which is abundant near Narkanda, and the seeds of *Pinus wallichiana* in Sungri.

After snowfall, the troops descended below the lower limit of snowfall and foraged the seeds of *Pinus wallichiana* on the ground, *Trifolium repens*, potato remnants and young leaves of wheat. Because of forest area was relatively small in the lower part of the home

range compared to the upper part around Narkanda or Sungri, the degree of dependence on the terrace fields became much higher.

As mentioned above, Rhesus monkeys travelled out of snow-covered areas, and so their travel distance and feeding behaviour were not influenced directly by snowfall. They avoided the worst conditions of snowfall in their habitat by changing the areas of utilization within the home range.

Intertroop relationships

In the survey areas, troops of Rhesus monkeys are distributed almost continuously, but each troop has its own home range. Here I describe the contact between troops, and the joining and parting of troops which travelled together for several days.

Intertroop relations were observed in Sungri on 12th December, 1972, and 16th, 17th and 19th January, 1973 (Fig. 9).

Observation 1 (12th December, 1972, at Nagadhar ridge):

Nagadhar ridge is in the home range of the Balun troop. On the 11th December the Balun troop was observed in the upper part of the ridge where it roosted in two groups separated by about 1 km. On the 12th, the troop was found in the place where it has spent the previous night, and then it moved slowly to the east, and appeared in the terrace fields beyond the Nagadhar ridge. This troop was composed of 96 individuals. Divided into 2 parts by the attack of a dog, 46 individuals escaped to the east, and 50 individuals to the west. The troop split very quickly, without confusion. The 46 individuals which went to the east travelled slowly for two days around Seri and Dugsa villages. On the other hand, the remaining 50 individuals stayed in the upper part of the forest around Balun village. It is almost certain that the group of 50 individuals is the Balun

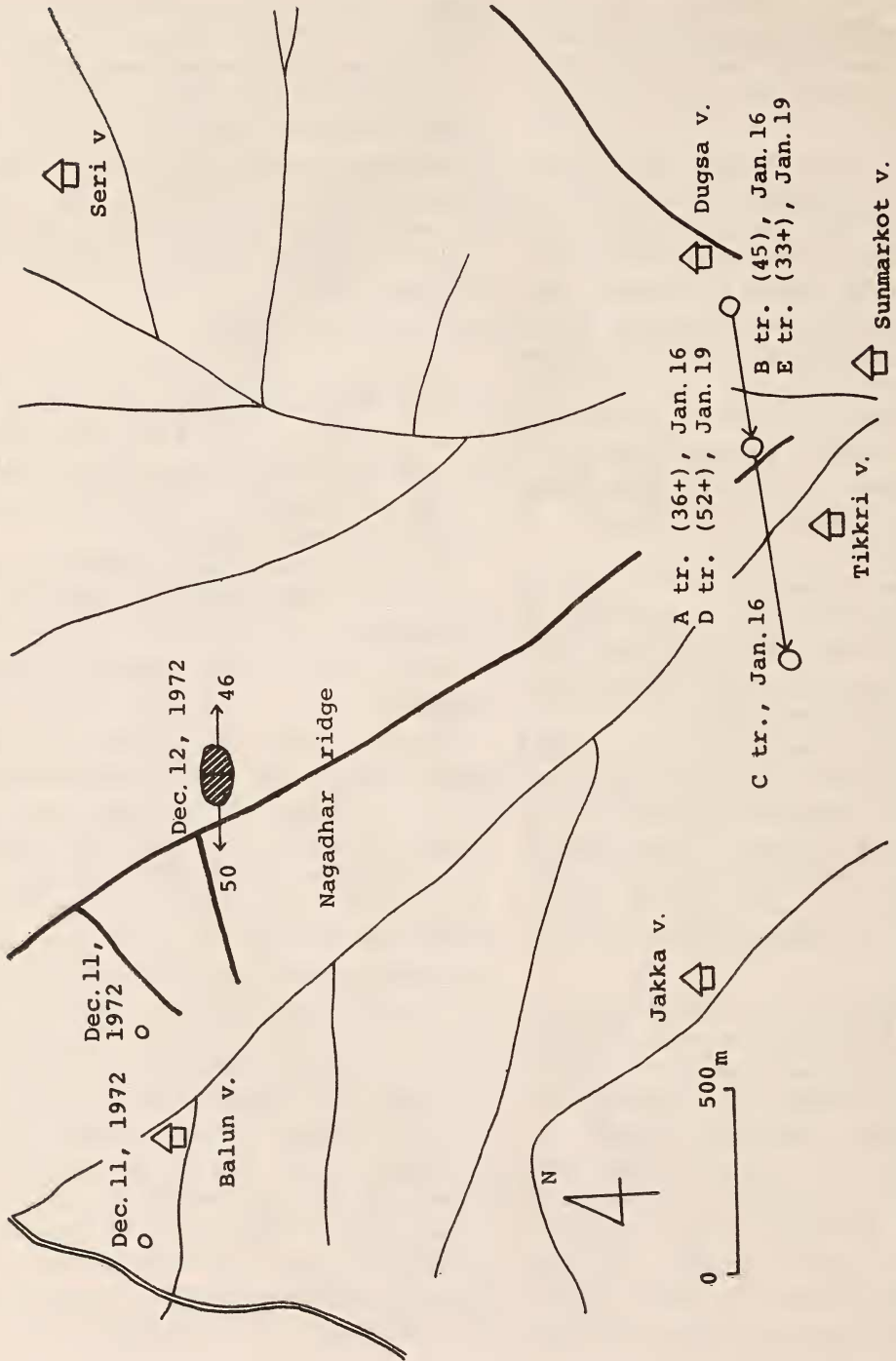


Fig. 9. Joining and dividing of troops at Sungri.

troop, which contained 68 individuals at maximum and that the other group of 46 individuals was the Seri troop.

Observation 2 (16th January, 1973 at Tikkri village):

Forty-five individuals (B troop) were found in the terrace fields near Tikkri village on 15th January, and they travelled to the vicinity of Dugsa village. On the following day, 45 individuals were found in the forest directly below Dugsa village, and 36+ α individuals (A troop) in the fields of Tikkri village. The B troop began to travel to the fields of Tikkri village, following the same course that it had taken the previous day. The top group of the travelling troop was composed of two adult females, one 1-yr-old and one 2-yr-old, and they approached the central part of the A troop, which was spread out in the fields. Hereupon, 8 adults in the central part of the A troop moved about 5 m toward high ground. Following them, the A troop started to move slowly to the upper part of the ridge, and the B troop followed the A troop. Both troops travelled about 1 km in 5 hr after joining: for 1.5 hr out of the 5 hr, the distance between the 2 troops was only 10 m.

Before the A troop met the B troop, the A troop may have been foraging in the terrace fields near Tikkri village with the C troop (Jakka troop), because footprints in the snow on the night of the 15th were traced along that line, and the C troop was observed 500 m away travelling slowly in the direction of Jakka village immediately after the joining of the A and B troops.

Thus, the movement of the 3 troops appeared to have been as follows: on the night of 15th the A and Jakka troops joined in the fields near Tikkri village and travelled together until the morning of the 16th. Immediately after parting from the Jakka troop, the A

troop joined the B troop. They travelled together all day long and roosted in the same place.

Observation 3 (19th January, 1973 at Tikkri village):

On 17th January, 45 individuals were found around Tikkri village, and 47 individuals around Dugsa village. On the following day, it was reported that both troops were around Dugsa village and Tikkri village at the same time.

On 19th January, 33+ α individuals (E troop) from Dugsa village crossed a brook and approached 52+ α individuals (D troop) in the fields near Tikkri village. This situation was exactly the same as the relation between the A and B troops on 16th January, i.e., moving to the terrace fields near Tikkri village along the same route that was taken on the 16th from the wheat fields below Dugsa village, the E troop approached the D troop, which was foraging in the fields. Three juveniles of the D troop (3- to 5-yr-old) attacked individuals of the E troop which were climbing the slope at a distance of 15 m with "Ga, Ga, Ga" calls. The top group of the E troop was composed of an adult female, 1-yr-old, 3-yr-old and an adult male, and 33+ α individuals of the E troop joined the D troop. There was no trouble during the contact between the 2 troops, and 86 individuals were eating together in the fields for about 3 hr.

When I observed the A.B.D.E. troops, no other troops were found in the survey area except the Jakka troop. It suggests that the 4 troops correspond to the Seri and Balun troops.

From the above-mentioned observations, the following conclusions can be drawn: 1) Some troops travelled together during certain periods, 2) When joined troops moved together, the individuals from each troop were not mixed but retained their identity as separate troops, 3) In the coming together of troops, there was little

antagonistic behaviour and 4) Converging of several troops occurred in early winter when snow cover was present for short periods, and occurred again more frequently when monkey troops moved to lower utilization areas after snowfall. As autumn sown wheat fields and potato fields were only seen around the Tikkri-Dugsa-Sunmarkot villages at low altitude, the monkey troops gathered in these limited areas and the chance of troop meetings increased.

Grouping through troop procession

Rhesus monkey troops are composed of individuals of both sexes and of all ages; the composition is very similar to that of the Japanese monkey troop. One small group of 3 adult males was found at Sungri, but continuity of the group was not observed.

The observation of individual groupings within the troop was limited to count of individuals crossing streamlets or spreading out in the terrace fields.

A) The grouping of troop processions: the number of individuals of a troop, its composition by sex and age, and its grouping structure were observed 14 times (Table 11). When troops were moving across forest slopes with feeding, they usually moved slowly with individuals scattering. However, when crossing streamlets, as in case 9, 12-14 of Table 11, all individuals of the troop usually moved simultaneously and rapidly for a short period along the same route. Since there were pauses among moving monkeys, it was possible to distinguish groups roughly. In all these cases the monkeys moved in several compact groups.

The grouping combination which occurred most frequently consisted of adult males and adult females with babies up to 3-yr-olds, accounting for 39% of all groupings. Juveniles were estimated at 4- to 6-yr-olds, and adults at 7-yr-old and over for both male and female. Babies in troop procession followed their

mother closely, or clung to her back or abdomen, while 1- to 3-yr-olds walked further away from their mothers. The position of adult males during troop movement varied.

Some 23% of the groupings consisted of adult females and babies to 3-yr-olds, and mothers were located at the center of groupings. The remaining 39% were as follows: 1) males only, 2) male and adult females, 3) juveniles of both sexes, 4) adult females and juveniles of both sexes, 5) adult females only, and 6) adult males and juveniles of both sexes.

Some features were noted in the order of individuals within each troop procession.

During rapid movement without feeding, the leading part of the procession was composed of adult males, adult females and babies to 3-yr-olds or adult females and babies to 3-yr-olds. In case 9, the top group consisted of a adult male with erect tail, 2 adult females with a baby, and 3-yr-olds. In case 13, adult females and babies to 2-yr-olds formed the top group. They crossed a rivulet and were the first to contact the A troop. Second and third groups without adult males crossed the rivulet, and then the tail-erecting adult male appeared 18 min after the top group had forded. At that time the top group had already joined the A troop. In case 12, the top group consisted of adult females and babies to 3-yr-olds.

It was not clear at which moment troops moved. However, when the troop had started to move, a male with erect tail in case 9, and a adult female in case 13 led troop orientation and the change of movement behavior.

The individuals consisting the top group during troop procession included two combinations: adult males, adult females and babies to 3-yr-olds, of adult females and babies to 3-yr-olds only. In the former case, the position of adult males in the group was not fixed.

ECOLOGICAL ADAPTATION IN RHESUS MONKEYS

Table 11. Procession composition at troop movement

No. of times	Date	Area observed	Troop	Grouping & Ind. no.	Ind. no.	Observed activity	Time (min)
1	Nov. 29, 1972	Narkanda	Nheri	● 22 11	33	Moving	2
2	Dec. 30, 1972	"	Doza	○ 5 6 2 1 13 X	27	"	19
3	Dec. 8, 1972	Sungri	Balun	○ 5 3 11 1 8 1 2 X	31	Moving and feeding	76
4	Dec. 9, 1972	"	"	○ 3 9 1 26 2 1 4 4 1 △	51	Moving	39
5	"	"	"	○ 28 1 5 4 1 2 2 X	43	"	11
6	Dec. 10, 1972	"	"	○ 5 4 13 4 ○	26	Moving and feeding	46
7	Dec. 12, 1972	"	Balun + Seri	● 4 2 1 X	96	"	66
8	"	"	Seri	○ 6 8 2 5 13 ○	34	"	.65
9	Dec. 13, 1973	"	"	○ 5 16 18 2 2 ○	43	Moving	11
10	Jan. 10, 1973	"	Balun	X 3	3	"	10
11	Jan. 15, 1973	"	"	● 11 8 5 ○	24	Moving and feeding	5
12	"	"	"	○ 23 24 ○	49	Moving	9
13	Jan. 16, 1973	"	B	○ 8 4 1 11 21 △	45	"	18
14	Jan. 17, 1973	"	"	○ 20 5 6 14 ○	45	"	8

○ Adult♂ + adult♀ + babies to 3-yr-olds
 ● Adult♀ + babies to 3-yr-olds
 ○ Adult♀ + juveniles
 X Observation example exactly traced till last ind. of troop
 □ Juveniles only
 ○ Adult♂ + adult♀
 △ Adult♀ only
 ○ Adult♂ + juveniles or babies to 3-yr-olds
 ● Adults estimated at more than 7-yr-olds
 ○ Juveniles estimated at 4- to 6-yr-olds

There were many adult males at the rear of troop processions. Among 8 examples observed in detail, a male with erect tail occupied the last position in one case. In 4 cases, a male and female pair occupied the rear position, and this may be related to the breeding season. Even if troop started to move, such pairs were slow to move, and as a result they remained in the last half of the troop procession.

In one example, 5 adult males occupied the rear of the troop procession with 21 individual groupings composed of adult males, adult females and babies to 3-yr-olds.

Therefore, the rear of troop processions consisted mainly of adult males in 6 out of 8 examples.

Once, the Doza troop was pursued and attacked by a medium-sized dog in the forests of Rela Nimla village near Narkanda. All the monkeys of the troop climbed into the canopy of *Pinus wallichiana* and ascended about 15 m from the dog. When the dog approached, a roughly 10-yr-old male stood on guard on the ground. He adopted a threatening posture with open mouth, but made no sound. The dog barked and approached within 10 m of the adult male. The animals faced each other in this way for several minutes. In the meantime, the other monkeys retreated. The adult male backed away slowly from the dog, in the direction of troop movement.

B) Groupings in a troop spread out in terrace fields: In all 18 cases, partial spacing of a troop was observed during feeding times. The most frequent groupings were adult females with babies to 2-yr-olds or adult males and adult females. In many cases adult males were solitary, but they did not quarrel even when converging into terrace fields with distances of 1-2 m between individuals.

The distribution changed according to the

size of the fields or forests in which feeding occurred. In the narrow sections of *Pinus wallichiana* along the brook of Narkanda, troops picked up seeds of *Pinus wallichiana* in a 100 m line along the brook slope.

In small wheat fields, e.g., 20 m x 20 m in area, individuals ate with parts of their bodies in contact. When they were spreading out to eat potato remnants on terrace fields, they ate sporadically over an area of 20 m x 50 m (Plate).

In spite of the variation of habitat sizes, the feeding area of a troop was usually within 100 m in diameter, with individual distances depending on the sizes of the terrace fields or forests. Thus, individual spacing corresponds to the feeding environment.

Grouping of adult females with babies to 3-yr-olds most frequently appeared during troop procession or feeding (Table 11).

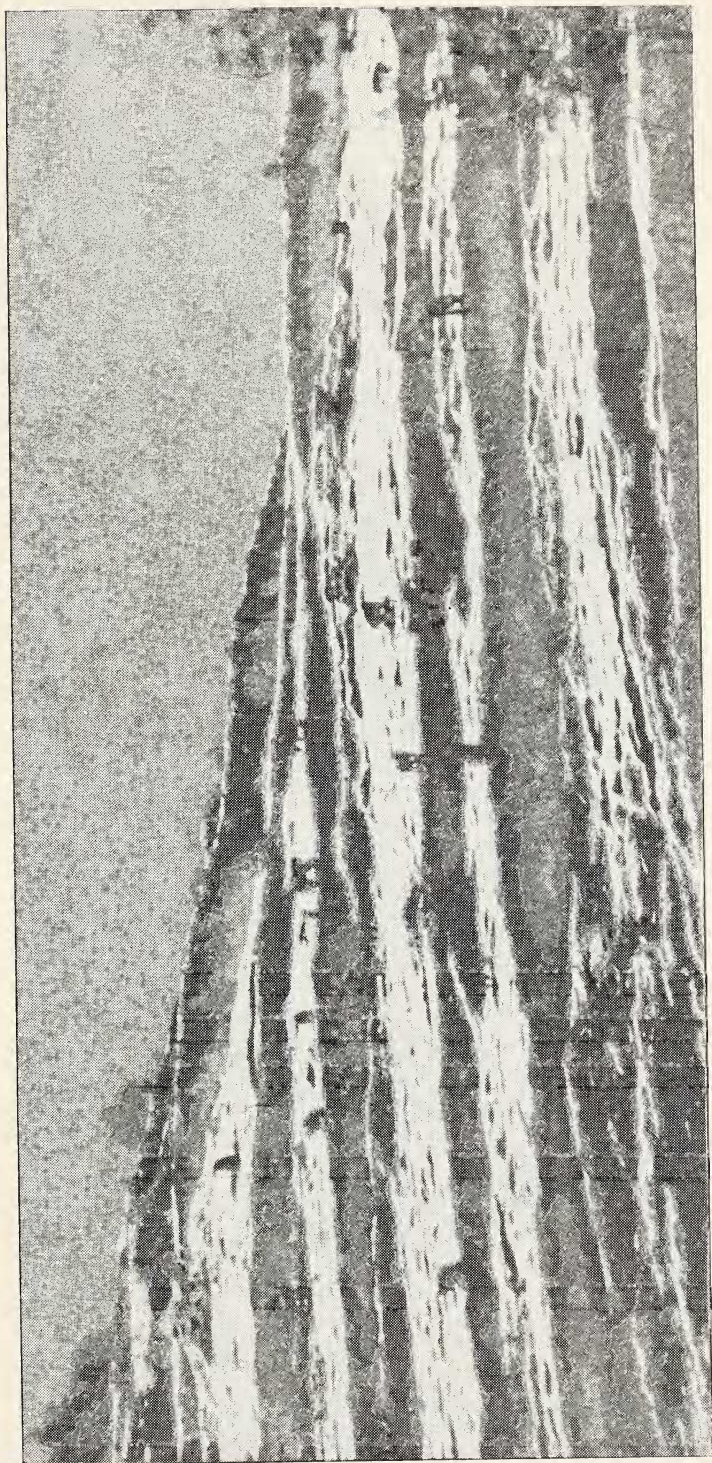
DISCUSSION

Determining factors of the upper limit of the Monkey distribution

As mentioned above, Rhesus monkeys include terrace fields in their home ranges as an essential part. The upper border of terrace fields and upper limit of the monkeys coincide with at 2,600 m a.s.l., so it could be suggested that the upper limit of the monkeys are closely related with the existence of terrace fields.

The type of forest and Monkey distribution

Rhesus monkeys in Simla, Kufri and Sunгри inhabit *Pinus*-dominated forests developed on southern slopes and terrace fields. *Cedrus deodara*-dominated forests usually spread on northern slopes. The northern slope of Narkanda, above Nheri village consists of *Cedrus deodara*-dominated forest where troops frequently utilized thick growth of *Vitis himala-*



Rhesus monkey feeding in terrace fields.
(Photo: K. Wada)

TABLE 12
ECOLOGICAL CHARACTERS OF RHESUS MONKEYS AND JAPANESE MONKEYS IN SNOWY AREAS

	Rhesus monkeys	Japanese monkeys
Habitat	Fields and pine forests	Deciduous and evergreen broad-leaved forests
Winter movement	Lowering of utilization areas below the limit of snowfall	Reduction of home ranges compared to summer: some lowering of ranges, but living in snowy areas
Winter food list	Nuts of <i>Pinus</i> spp., grasses, potatoes, young leaves of wheat	Buds and bark of deciduous broad-leaved trees
Snow conditions	Continental climate; sometimes ground surface exposed on southern slopes below 4,000 m a.s.l.	Covering ground throughout winter; air temperature minimum, — 20°C (colder than at 4,000 m a.s.l. in the Himalayas)

yana as staple food. Huge forests, especially of *Cedrus deodara*, remain on the northern slopes along the ridge through Simla to Sungri via Narkanda, while the southern slopes are less forested. Rhesus monkeys were never found in these forests, and *Cedrus deodara* forests bordering terrace fields were little utilized (i.e., the *Cedrus deodara*-dominated forests between Sungri and Rampur, and on the northern slopes in Kufri and Narkanda). *Cedrus deodara*-dominated forests are not suitable as monkey habitats, because seeds of *C. deodara* are little utilized as food, and there is only limited food even in the undergrowth. In autumn, these forests did not supply feeding materials except for *Vitis himalayana*. Therefore, the preferred habitats for monkeys were locations with intermixed *Pinus*-dominated forests and terrace fields on southern-facing slopes under cultivation. Thus, monkey troops were more continuously distributed on southern slopes than on northern slopes (Figs. 3, 4 and 5).

Ecological adaptation to snowfall

The characteristics of Rhesus monkeys and Japanese monkeys in snowy areas are compared in Table 12. The differences of ecological characteristics are clearly related to the feeding environments. Snow cover in coniferous forest in winter restricts Rhesus monkeys' food to seeds within the cones on branches of *Pinus wallichiana*. When snowfall during the end of November and mid-December melts within a few days, forest undergrowth is exposed, and the troops do not change their areas of utilization. After the end of December, snow falls very often, and the troops change their areas of utilization as acquisition of foods becomes difficult. So changes in the area of utilization should not be affected by the lower-

ing of ambient temperature, but rather, by the snow cover.

On snow-covered coniferous forests there are fruits of *Aesculus indica* (deciduous broad-leaved) and of *Quercus incana* or *semecarpifolia* (evergreen broad-leaved), but monkeys tend to eat mainly from *Pinus*.

Japanese monkeys inhabiting snowy forests through winter do not lower their areas of utilization to areas free from snow cover. They winter on buds and bark of deciduous broad-leaved trees in conjunction with their subcutaneous fat accumulated in autumn (Wada 1964). Although conifers distributed sporadically in deciduous broad-leaved forests supply roosting sites for Japanese monkeys, they do not offer food resources for the monkeys. There is a severe food deficiency in coniferous forests, so the distributional expansion of Japanese monkeys into coniferous forests is prevented (Wada & Ichiki 1980).

As discussed above, Rhesus monkeys are able to spread into secondary coniferous forests formed from mixed broad-leaved forests for the following reasons: (1) There are many seeds of *Pinus wallichiana* in coniferous forests as staple food in winter; and 2) Below 3,000 m a.s.l. in winter, the snow melts within a few days, and the ground surface is exposed, making food available again. It is possible that the food supply of Rhesus monkeys in winter is more abundant than in the case of Japanese monkeys in snowy districts, so in autumn Rhesus monkeys do not need to build up reserves of fat.

Rhesus monkey movements and terrace fields

In general, monkeys included in the genus *Macaca* appear in cultivated fields to feed on crops. Japanese monkeys displaced by extensive destruction of huge forest areas approach hills around fields, and then cause damage to many kinds of crops. As farmers in Japan

practice intensive cultivation, there is always a conflict of interests. Therefore it is difficult to be sure that Japanese monkeys include fields in their home ranges.

In China too, Rhesus monkeys, Red-faced monkeys and Pigtailed monkeys are violently ejected from fields (Shaw 1962). In India, especially in the lower Himalayas, Rhesus monkeys certainly include terrace fields in their home ranges. The monkeys find potato remnants, grasses belonging to the Gramineae, corn, peas and young leaves of wheat as food in the fields. Indian farmers do not rigorously exclude monkeys from fields because cultivation is less intensive, and the monkeys are regarded as servants of Hindu gods. When monkeys pick up potato remnants, the farmers are indulgent. More valuable crops are protected rigorously with fire crackers. The Rhesus monkeys' menu includes nuts, seeds, fruits, young leaves and stems of plants, so cultivated crops in fields become a part of natural habit of fruit and seed feeding. On the other hand, the staple foods of Himalayan langurs are fruits and leaves of trees (Sugiyama 1976), crops in fields are eaten as substaple foods. So the langurs appear less in fields than Rhesus monkeys. In view of the different utilization of fields between the two monkeys, it would be interesting to compare their adaptability to environmental changes.

Sociological function of groupings in troop procession

As seen above, the grouping of adult females with babies to 3-yr-olds most frequently appeared during troop processions. It suggests that this is very important grouping in the troop structure.

As I described about the Doza troop, a fully adult male faced against a dog on the ground. If there is a dog near a troop, the monkeys move